Near-Shore Migratory Behaviour and Exploitation of Maturing Pink Salmon *(Oncorhynchus gorbuscha)* from the Canadian Department of Fisheries and Oceans Statistical Area 6 in 1985

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NEAR-SHORE MIGRATORY BEHAVIOUR AND EXPLOITATION OF MATURING PINK SALMON (Oncorhynchus gorbuscha) FROM THE CANADIAN DEPARTMENT OF FISHERIES AND OCEANS STATISTICAL AREA 6 IN 1985

by

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ABSTRACT

Henderson, M. A. 1987. Near-shore migratory behaviour and exploitation of maturing pink salmon (Oncorhynchus gorbuscha) from the Canadian Department of Fisheries and Oceans Statistical Area 6 in 1985. Can. Tech. Rep. Fish. Aquat. Sci. 1621: 21 p.

Maturing pink salmon were caught in 12 fisheries in northern British Columbia and southern southeast Alaska on their return migration to spawning areas in the Canadian Department of Fisheries and Oceans Statistical Area 6 in 1985. Generally, the fish were present in the more northerly fisheries between late June and August. Swimming velocity of the maturing pink salmon during their coastal migration ranged from 20 to 30 km per day. There were major differences in the timing of individual Area 6 origin pink salmon stocks through the Area 6 fishery with some stocks reaching their greatest abundance as much as a month before others. The overall exploitation rate on Area 6 origin pink salmon in 1985 was approximately 60%.

RÉSUMÉ

Henderson, M. A. 1987. Near-shore migratory behaviour and exploitation of maturing pink salmon (Oncorhynchus gorbuscha) from the Canadian Department of Fisheries and Oceans Statistical Area 6 in 1985. Can. Tech. Rep. Fish. Aquat. Sci. 1621: 21 p.

En 1985, on a capturé à douze pêcheries au nord de la Colombie-Britannique et au sud sud-est de l'Alaska des saumons roses en voie de maturation lors de leur remonte aux frayères du secteur statistique n^{0} 6 de Pêches et Océans Canada. De façon générale, les poissons étaient présents aux pêcheries situées au nord entre la fin juin et le début d'août et aux pêcheries du sud entre la fin juillet et la fin d'août. La vitesse de nage de ces saumons roses lors de leur migration vers la côte variait de 20 à 30 kilomètres par jour. On a observé des différences importantes en ce qui a trait au moment de passage de stocks de saumons roses originaries du secteur 6 dans la pêcherie de ce secteur, certains stocks atteignant leur plus grande abondance jusqu'à un mois avant les autres. Le taux global d'exploitation de saumons roses originaires du secteur 6 en 1985 a été d'environ 60%.

INTRODUCTION

Pink salmon have formed a major component of the total commercial salmon catch in British Columbia since 1877 (Argue et al. 1986). Since 1951 the annual British Columbia commercial pink salmon catch has ranged from approximately 2.5 million pieces to over 24 million pieces with an average of 11 million pieces. Although pink salmon can be found in coastal rivers throughout the Province, most of the production derives from a few large rivers or groups of adjacent rivers (Henderson and Charles 1984; Walters and Cahoon 1985). One of these important pink salmon production systems lies within the boundaries of the Canadian Department of Fisheries and Oceans Statistical Area 6 (Fig. 1).

Statistical Area 6 lies on the central coast of British Columbia between approximately 52°20' and 54°20' north latitude (Fig. 1). Salmon are known to spawn in 119 rivers and streams in Area 6. Although most of these systems support spawning populations of pink salmon, production from Area 6 is dominated by a few of the larger systems which include the Kemano, Kitimat, Quaal, Green and Khutze rivers and Arnoup, Scow Bay, Soda and Limestone creeks. The Area 6 pink salmon fishery, located in the immediate vicinity of Gil Island, is designed to harvest Area 6 origin pink salmon in excess of spawning escapement requirements and operates between early July and late August.

Despite the magnitude of Area 6 pink salmon stocks and their importance to the commercial fishing industry, little is known about the near-shore migratory behaviour of these salmon during the adult phase of their life history or the harvest patterns resulting from commercial fisheries. Without such information, it is extremely difficult to regulate fisheries so as to achieve management goals for these stocks.

An adult pink salmon tagging program was carried out in Statistical Area 6 in 1985. This program was part of a larger study designed to determine the proportion of many different pink salmon stocks in various major fisheries in northern British Columbia and southern southeast Alaska (Taylor et al. 1986). In addition to providing information on stock proportions, the tagging program also generated data that could be used to describe the near-shore migratory behaviour of Area 6 adult pink salmon. The purpose of this report is to present information on the near-shore migratory behaviour of Area 6 adult pink salmon, the location of fisheries intercepting Area 6 pink salmon, their timing through these fisheries and the travel time of Area 6 pink salmon between the different fisheries. In addition, estimates of the harvest of Area 6 adult pink salmon are provided for 1985 for all fisheries where these fish were known to occur.

METHODS

Adult pink salmon were tagged in 12 fisheries in southern southeast Alaska and northern British Columbia in 1985 (Fig. 2). Of the approximately 100,000 tags applied, 5,748 were subsequently recovered from commercial fisheries and from various spawning locations in Canada. Only tags recovered from examining a known sample size of pink salmon were used in the analyses presented in this report. Further details on the design and implementation of the 1985 tagging study and in the analysis leading to estimates of pink salmon stock composition by fishery are provided in Taylor et al. (1986).

Each tag applied to a pink salmon was imprinted with a unique number. In addition, each time a tag was applied it was associated with a particular release time and location (fishery). Consequently, it was possible to use tags recovered in Area 6 streams to determine what fisheries in the study area harvested Area 6 origin pink salmon and the period of time these fish were present in the various fisheries.

Estimates of the time it took pink salmon to move from different fisheries to the Area 6 fishery were based on known dates for tag release and recovery. However, it was not possible to estimate the travel time from any of the fisheries to spawning locations in Area 6. Although 25 streams and rivers in Area 6 were surveyed for tags, the time between surveys on any particular system was generally 7-10 days. As a result, it was not possible to determine the exact date when tagged fish arrived in spawning areas.

Estimates were derived for the run timing of three components of the Area 6 pink salmon stock complex through the Area 6 fishery; Quaal River pink salmon, Kitimat River pink salmon, and combined Area 6 pink salmon. The number of tags recovered in individual systems outside the Quaal and Kitimat rivers were not sufficient to permit a detailed evaluation of run timing for other stocks.

The run timing curve for the Quaal River pink salmon through the Area 6 fishery was determined in the following manner. First, the effective number of tagged pink salmon released from the Area 6 fishery was determined by release date. The effective number of tags released was estimated by subtracting the number of tags caught in the Area 6 fishery from the total number of tags released in the Area 6 fishery with both stratified by release date. The number of tags from a particular release date taken in a fishing period was determined by taking the product the number of tags from a particular release date taken in a fishery sampled at a known rate and the inverse of the sampling rate. Finally, to determine the effective number of tags released, this number was multiplied by the estimate of the proportion of the Area 6 pink salmon catch originating from Area 6 rivers and streams by release date. This step was necessary as the proportion changes over the season.

The next step involved determining the number of tags recovered in the Quaal River stratified by release date in the Area 6 fishery. These recoveries were then expressed as the number of recoveries in the Quaal River per one thousand tags released in the Area 6 fishery. This was accomplished

by taking the product of the total number of tags recovered in the Quaal River by release date and 1000 divided by the effective number of tags released for the same date. Estimates of recoveries per one thousand releases by release date were then scaled with respect to each other with the largest number of recoveries set at 1.000. The run timing through the Area 6 fishery for pink salmon destined for the Kitimat River was derived in the same manner.

It was not possible to develop a composite timing curve through the Area 6 fishery reflecting all Area 6 origin pink salmon stocks in the way it was done for Quaal and Kitimat river stocks. However, it was possible to develop an approximation of the timing curve based on the catch per unit of effort (CPUE) of commercial seine and troll vessels and the seine vessel used for tagging in the Area 6 fishery.

Estimates of the proportions of Area 6 origin pink salmon in the fisheries in the study area are from Currie (1986). These estimates were used to determine the total catch of Area 6 origin pink salmon in 1985.

RESULTS

NEAR SHORE MIGRATORY BEHAVIOUR

Fifty-seven pink salmon were tagged at nine different locations outside of Statistical Area 6 and subsequently recovered in Area 6 streams (Fig. 3). Area 6 pink salmon were present in Alaska Districts 104 and 101-11 between late July and mid-August, although the number of tags recovered from these locations was small. The small number of tags recovered from Alaska reflects, in part, the relatively low proportion of Canadian origin pink salmon in U.S. waters in 1985 (see below). A better indication of the period over which Area 6 pink salmon were present in the more northerly, outside waters of the study area was provided by the 19 tag recoveries that originated from Canadian Statistical Area 1-2. These tags were released in Area 1-2 over the period from late June to early August. Two tag recoveries of fish released in Canadian statistical areas adjacent to 1-2, 101-4 and 101-8, fell within the same time period. In contrast, recoveries of pink salmon tagged in Canadian statistical areas 101-7, 3-1 and 5-2, indicated that Area 6 pink salmon were present in these locations beginning in the latter part of July and persisting through the end of the tagging operation on August 31.

Tagged pink salmon took approximately 13 days to move from the most northerly tagging location in the study area, Alaska District 104, to the vicinity of the Area 6 seine fishery (Fig. 4). Based on the most direct route, this corresponds to a swimming velocity of 30 km per day. Travel time from tagging locations become closer to the Area 6 fishery. Swimming velocity also decreased to approximately 25 km per day from Area 1-2 and 21 km per day from Areas 3 and 5.

There appears to be major differences in the time period over which individual Area 6 pink salmon stocks were present in the vicinity of the Area 6 fishery (Fig. 5). Pink salmon tagged in the Area 6 fishery were recovered in 20 Area 6 streams. Some stocks such as those destined for Quaal and Khutze rivers and Gravel Lake and Foch creeks were caught in the area of Gil Island in early July while several other stocks were not encountered until a month or more later. However, most stocks did persist in the vicinity of the Area 6 fishery through the second half of August.

The limited number of tags recovered from most Area 6 streams precluded attempts to derive run timing curves at the Area 6 fishery for all stocks, excluding those from the Quaal and Kitimat rivers (Fig. 5). Both Quaal and Kitimat river origin pink salmon first appeared in the Area 6 fishery in early July, with a peak in abundance in mid to late July. Both stocks disappeared from the fishery between early and mid-August. The timing curves approximated a normal distribution with a slight skewness to the right. Although it was not possible to estimate the timing of all Area 6 stocks combined through the fishery based on CPUE data. Commercial seine and troll CPUE data and CPUE data from the tagging vessels all indicated a gradual increase in the number of pink salmon in the vicinity of the Area 6 fishery beginning in early July and reaching a maximum in mid-August. The peak in abundance as reflected by the CPUE data for the aggregate of Area 6 stocks is approximately one month later than that observed for the Quaal and Kitimat stocks.

HARVEST PATTERNS

The Area 6 pink salmon catch has shown a high level of interannual fluctuation since 1951 (Fig. 6). Over this period the even-year catch has been larger than that taken from odd-year runs and on two occasions exceeded four million pieces. These large even-year Area 6 pink salmon fisheries have, on average, accounted for almost 20% of the total British Columbia pink salmon catch since 1951 (Fig. 7). Area 6 fisheries operating in odd-years account for only one third of this amount.

About 1.5 million Area 6 pink salmon were harvested in at least 12 fisheries in 1985; four in Alaska and eight in British Columbia (Table 1). Approximately 85% of the total catch, or 1.26 million pink salmon, were taken in the terminal Area 6 fishery in the vicinity of Gil Island (Fig. 1). Of the remaining Canadian fisheries, only those in Dixon Entrance harvested substantial numbers of Area 6 origin pink salmon. The impact of U.S. fisheries on Area 6 pink salmon was small with the total U.S. harvest representing only 3.6% of the total 1985 harvest from this stock complex.

The total spawning escapement of pink salmon to Area 6 in 1985 was 1,062, 132 (R. Goruk, Canadian Department of Fisheries and Oceans, Prince Rupert, pers. comm.). The escapement, and catch combined produced a total stock size in 1985 of 2,543,322. The resulting exploitation rate was 58.2%.

DISCUSSION

Maturing pink salmon destined for spawning areas in British Columbia move from the Gulf of Alaska in a southeasterly direction (Manzar and Shepard 1962). However, the location where these fish first encounter the coast and their following migratory behaviour near the coast is less certain. Several studies have shown that some of the maturing pink salmon tagged in southeast Alaska are subsequently recovered in areas of British Columbia north of Vancouver Island (Manzar and Shepherd 1962). The current study confirms these results with respect to Statistical Area 6. In our study, we have documented the presence of Statistical Area 6 origin pink salmon in four fisheries in Alaska and seven fisheries in British Columbia north of Statistical Area 6. Together, the Statistical Area 6 tag recoveries suggest a migration route from southeast Alaska, east through Dixon Entrance and south along the coast of British Columbia to Statistical Area 6. This study however, does not discount the existence of other coastal migratory routes for maturing pink salmon destined for Statistical Area 6. For example, it is possible that some portion of the Area 6 stock aggregate may move south along the west side of the Queen Charlotte Islands and then east to Statistical Area 6 through Hecate Strait. Currently, there is no direct evidence to support the existence of such a migratory route. However, an earlier tagging study has shown that some maturing pink salmon tagged in Statistical Area 7 (i.e. south of Statistical Area 6) were moving to spawning locations in Statistical Area 6 (Anonymous 1982). This behaviour could be explained by a migratory route along the west coast of the Queen Charlotte Islands, east through Hecate Strait, and then north to Statistical Area 6.

The possible existence of other coastal migratory routes in addition to the one shown in this study has important implications for the Statistical Area 6 pink salmon stock complex. The estimated exploitation rate for the stock in 1985 based on catches in Statistical Area 6 and north of Statistical Area 6 was 58.2% (Table 1). This is considerably higher than the estimated optimum exploitation rate of 43% for odd-year pink stocks for Areas 6 through 10 based on a stock-recruitment analysis of catch and escapement statistics for the years 1947 through 1979 (Beacham 1984). However, the optimum exploitation rate estimated by Beacham is somewhat less than the "true" optimum exploitation rate as he did not account for the catch of Area 6 origin pink salmon taken outside the Area 6 fishery. Nevertheless, the relatively large differences between the 1985 exploitation rate and the estimated optimum exploitation rate combined with the proportionally small catch of Area 6 origin pink salmon outside the terminal fishery suggests that the 1985 exploitation rate should not be exceeded for odd-year Area 6 pink salmon. The existence of migratory routes that would bring pink salmon from the Area 6 stock complex to the vicinity of other fisheries not included in the 1985 study may further increase the "true" exploitation rate.

Large pink salmon tagging programs similar to the 1985 program described here were conducted in 1982 (Gazey et al. 1983) and 1984 (English et al. 1985). One of the major differences was that tagging did not take place in Statistical Area 6 in these two years. Nevertheless, pink salmon tagged in

southern Alaska and northern British Columbia in 1982 and 1984 were recovered in Statistical Area 6. This suggests that the general coastal migratory pattern of Area 6 origin maturing pink salmon observed in 1985 was not unusual but rather, probably typical of most years.

Although the timing and pattern of migration for the Area 6 pink stock complex does result in Area 6 fish passing through pink salmon fisheries in southeast Alaska and northern British Columbia it appears these fisheries have little impact on the total catch from this stock complex. This is particularly true for the fisheries in Alaska where the proportion of the total catch consisting of Area 6 origin pink salmon was never greater than one percent (Table 1). This situation should persist as long as the relative abundance of maturing pink salmon destined for southern southeast Alaska and northern British Columbia does not change dramatically. The incidence of Area 6 origin pink salmon caught in British Columbia fisheries outside Area 6 was somewhat higher (Table 1), but again the contribution to the total catch of this stock was minimal. Clearly, any attempt to substantially alter the overall harvest rate on Area 6 pink salmon would have to be accomplished through changes to the Area 6 fishery.

Area 6 origin pink salmon were present in the vicinity of the Area 6 pink salmon fishery for approximately two months in 1985 (Fig. 5). Over this period some stocks such as those from the Kitimat and Quaal rivers peaked in abundance more than a month prior to other stocks. This difference in timing should be useful in structuring the Area 6 fishery in such a way as to increase or decrease the exploitation on specific stocks or stock grouping. For example, in 1985 the Area 6 seine and gillnet fisheries did not begin until the end of July. By this time most of the pink salmon from the Kitimat and Quaal rivers had moved out of the vicinity of the Area 6 fishery on their way to the spawning grounds.

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Table 1. Proportion and catch of Area 6 origin pink salmon by fishery for 1985.

Fishery	Total pink salmon catch	Proportion Area 6 fish		Catch of Area 6 fish
U.S.				
Noyes	6,755,700	0.003		20,267
Muzon	2,414,079	0.010		24,141
Upper Clarence	991,220	0.000		0
Lower Clarence	4,579,932	0.001		4,580
Cordova	2,389,150	0.000		0
Fox	691,147	0.007		4,838
			Subtotal	53,826
Canada				
Dixon Entrace				
Area 101	687,034	0.078		53,589
Area 1-2	236,623	0.211		49,927
Area 3X	172,645	0.085		14,675
Area 3Y	910,958	0.007		6,377
Area 3Z	1,574,235	0.002		3,148
Area 4	1,728,092	0.015		25,921
Area 5	1,297,021	0.045		13,366
Area 6	1,522,175	0.828		1,260,361
			Subtotal	1,427,364
			Total	1,481,190

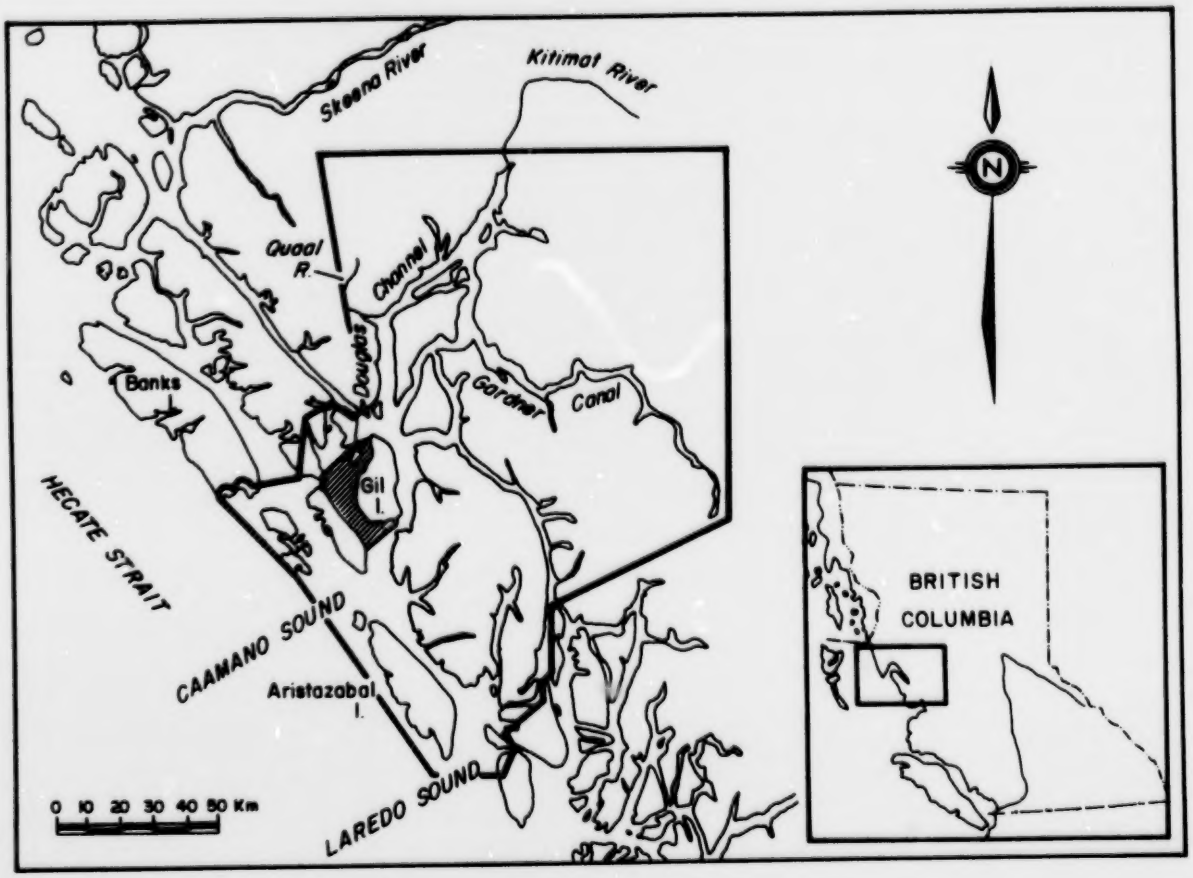


Fig. 1. Boundaries of Statistical Area 6. The shaded area indicates the location of tagging sites in Statistical Area 6.

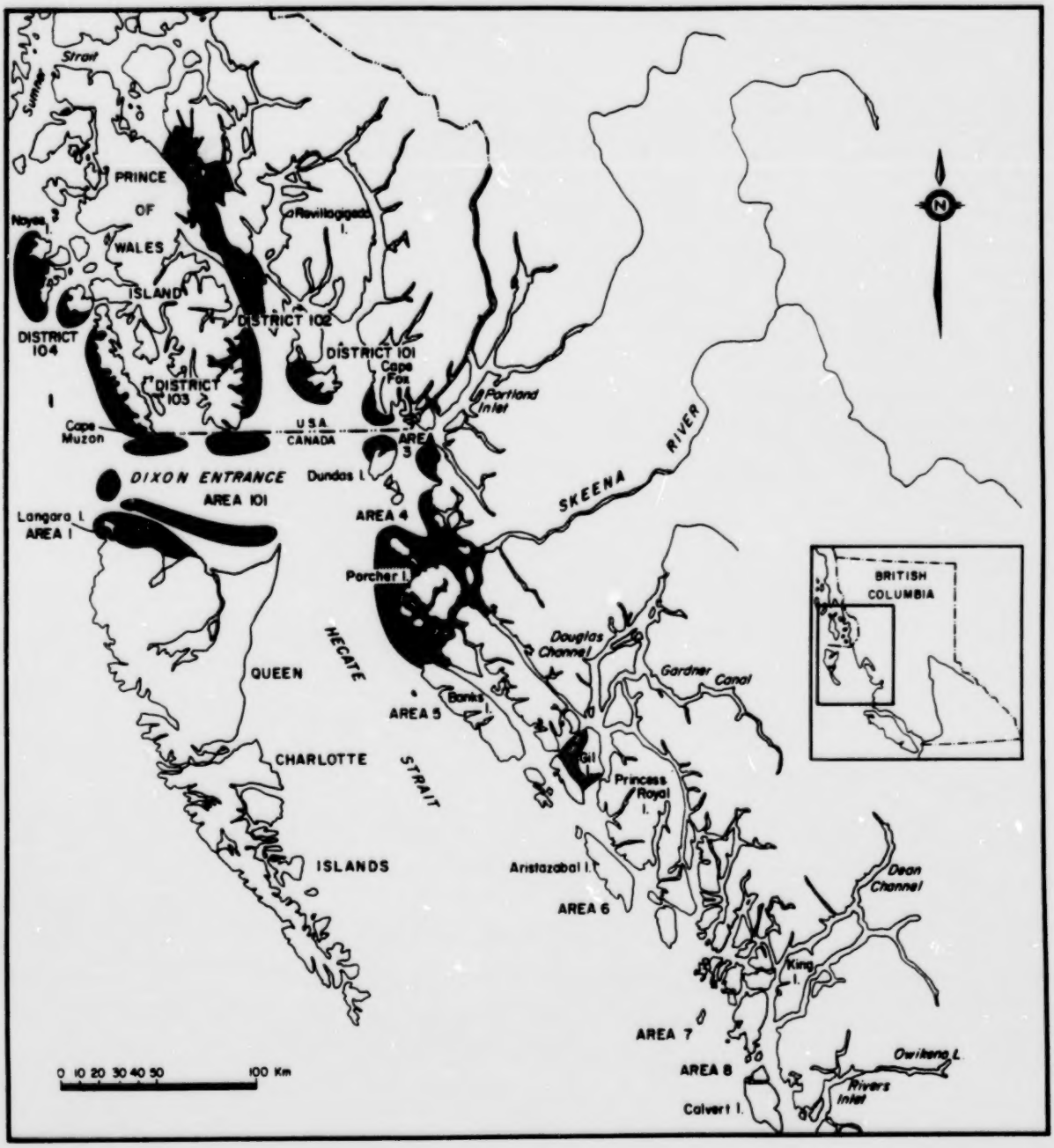


Fig. 2. Study area in northern British Columbia and southern southeast Alaska. Shaded areas indicate the locations of tagging sites.

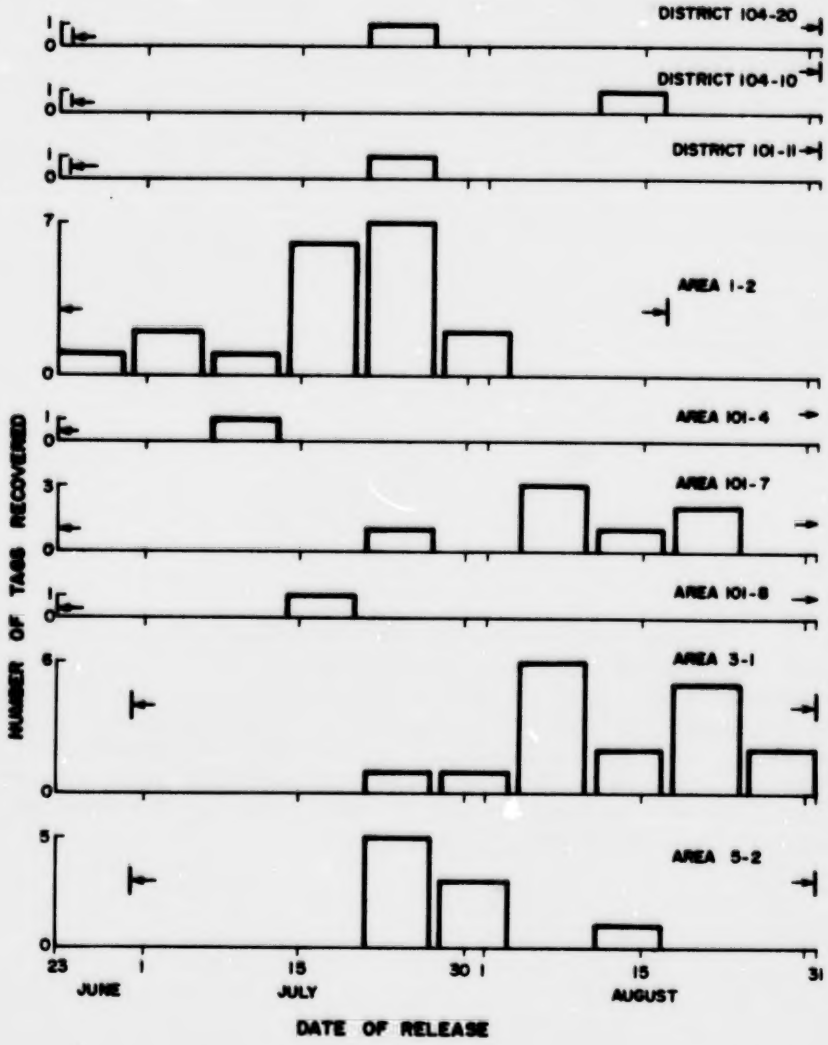
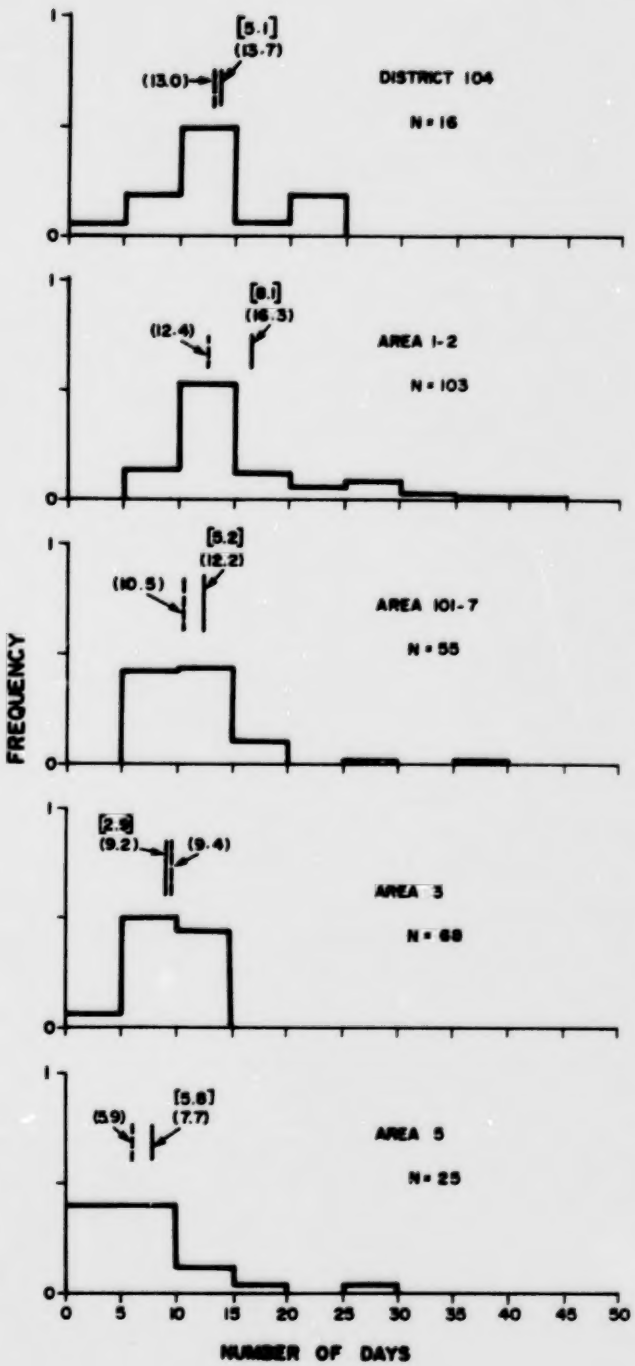


Fig. 3. Number of tags recovered from Area 6 pink salmon streams for different release sites and release dates in 1985. Tag recoveries are grouped by week beginning with the week ending June 29. Arrows indicate the period over which tags were released at each site.

Fig. 4. Frequency distribution of the number of days taken by tagged pink salmon to move from release sites (fisheries) in northern British Columbia and southern southeast Alaska to the Area 6 fishery in 1985. Tag recoveries are grouped at five day intervals. The median and mean are represented by vertical broken and solid lines respectively. The standard deviation of the mean is shown above the mean in square parentheses. N indicates the number of tags recovered.


[5.1]
(13.7)
(13.0)
DISTRICT 104
N = 16
[8.1]
(16.3)
(12.4)
AREA 1-2
N = 103
[5.2]
(12.2)
(10.5)
AREA 101-7
N = 55
FREQUENCY
[2.9]
(9.2)
(9.4)
AREA 3
N = 68
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(7.7)
(5.9)
AREA 5
N = 25
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NUMBER OF DAYS

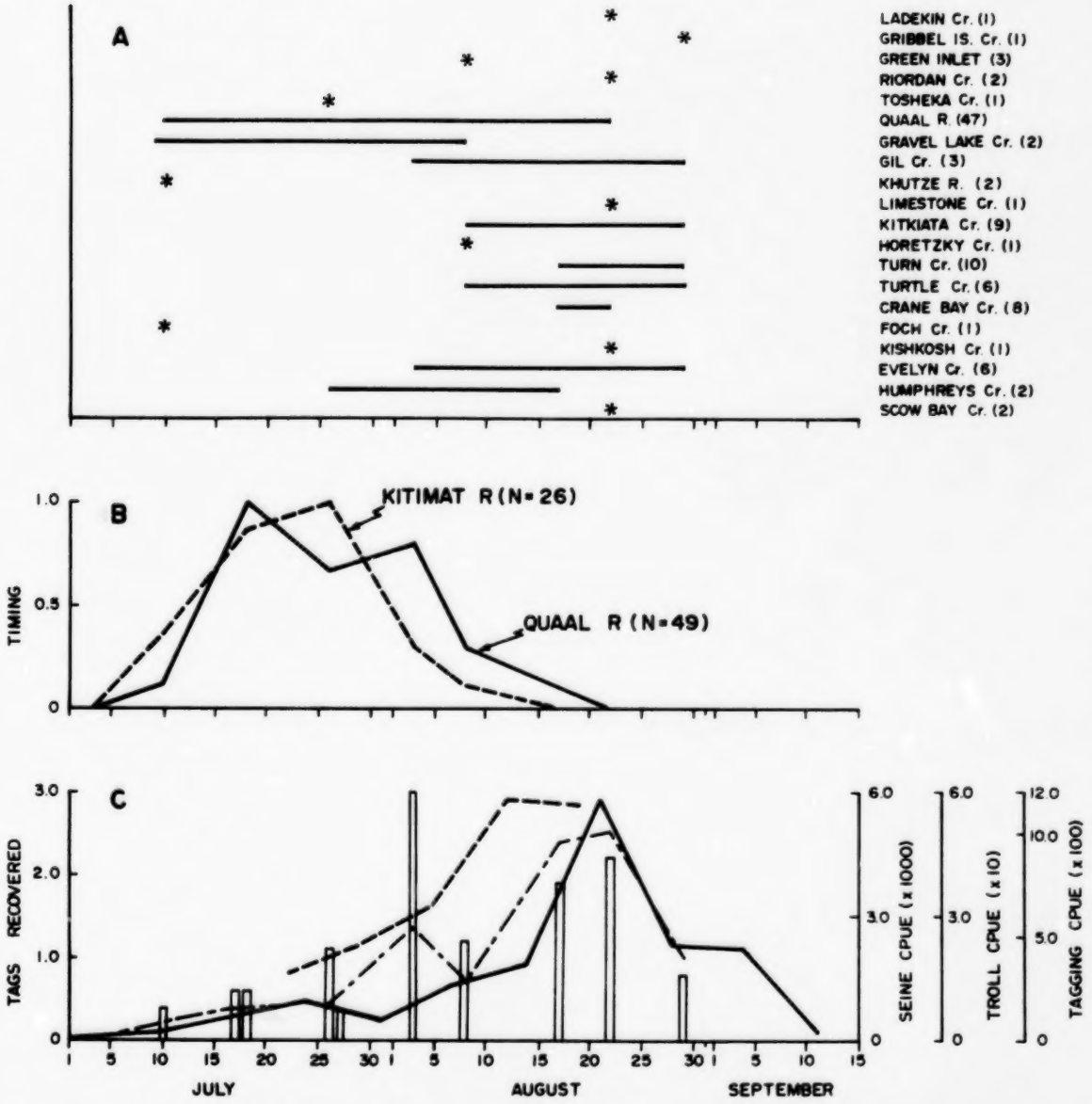

Fig. 5. Timing of various Statistical Area 6 origin pink salmon stocks through the Area 6 fishery in 1985. Part (A) shows the date tagged pink salmon were released in the Area 6 fishery that were subsequently recovered from various Statistical Area 6 spawning locations. Numbers in parentheses indicate the number of tags recovered from each spawning area. Horizontal lines show the range of dates for tag releases where more than one recovery was made. Part (B) shows the timing of Quaal and Kitimat river origin pink salmon through the Area 6 fishery. Part (C) shows the catch-per-unit-effort (CPUE) for commercial seine ( ), and troll ( ) vessels and the tagging seine vessel ( ) in the Area 6 fishery. Vertical bars show the number of tags released in the Area 6 fishery by release date that were subsequently recovered in spawning areas in Statistical Area 6. See text for details.

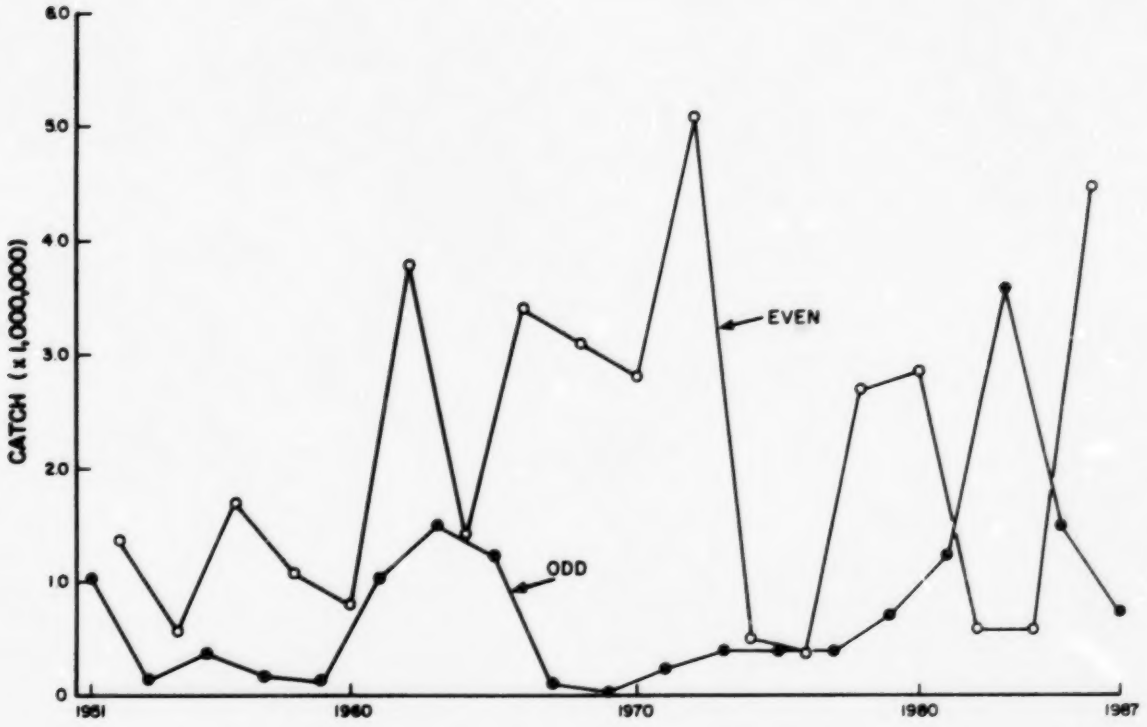

Fig. 6. Catch of pink salmon in Statistical Area 6 in odd and even years from 1951 to 1987 inclusive.

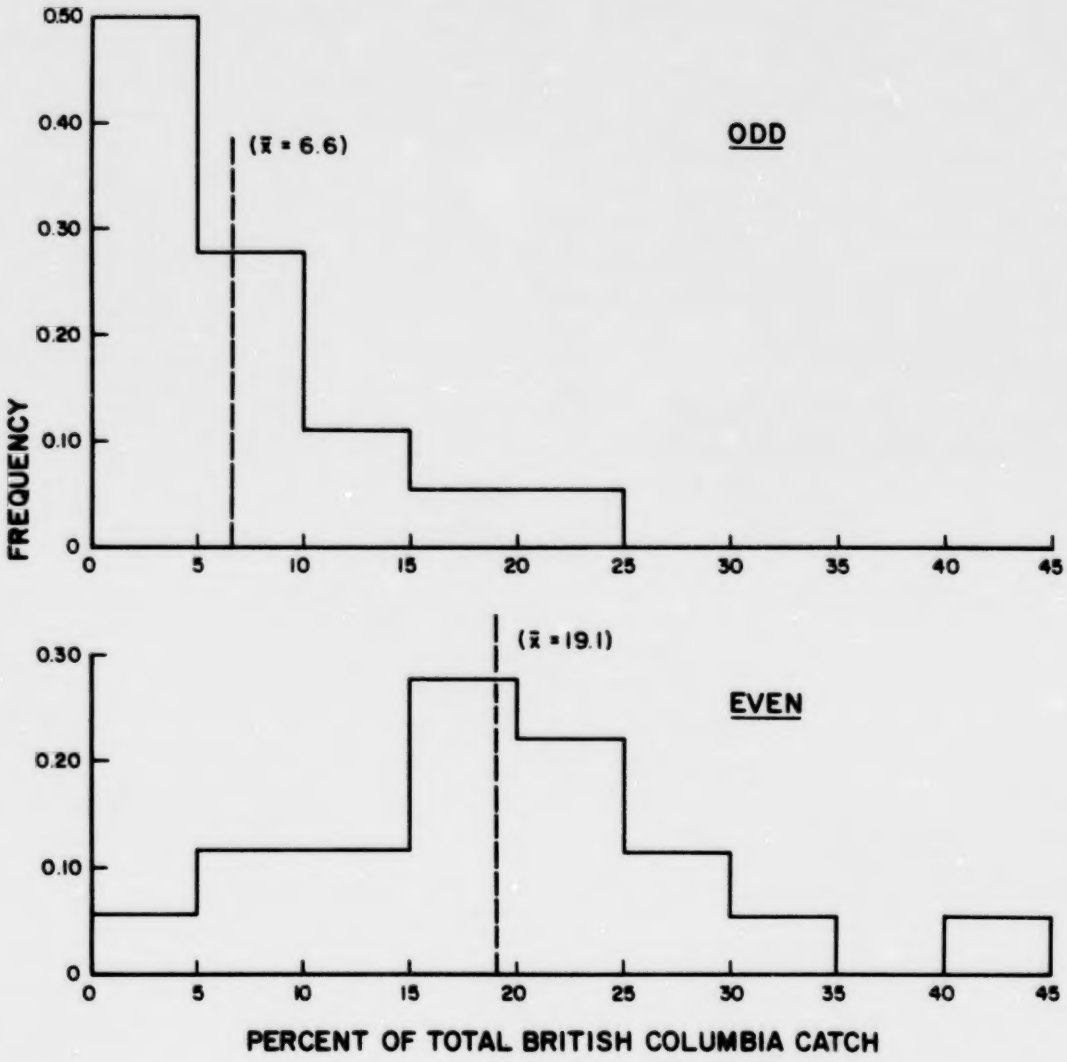

Fig. 7. Frequency distribution of the percent of the total British Columbia pink salmon catch taken in Statistical Area 6 in odd and even years from 1951 to 1987, inclusive. The broken vertical lines show the average percent Area 6 pink salmon catch.